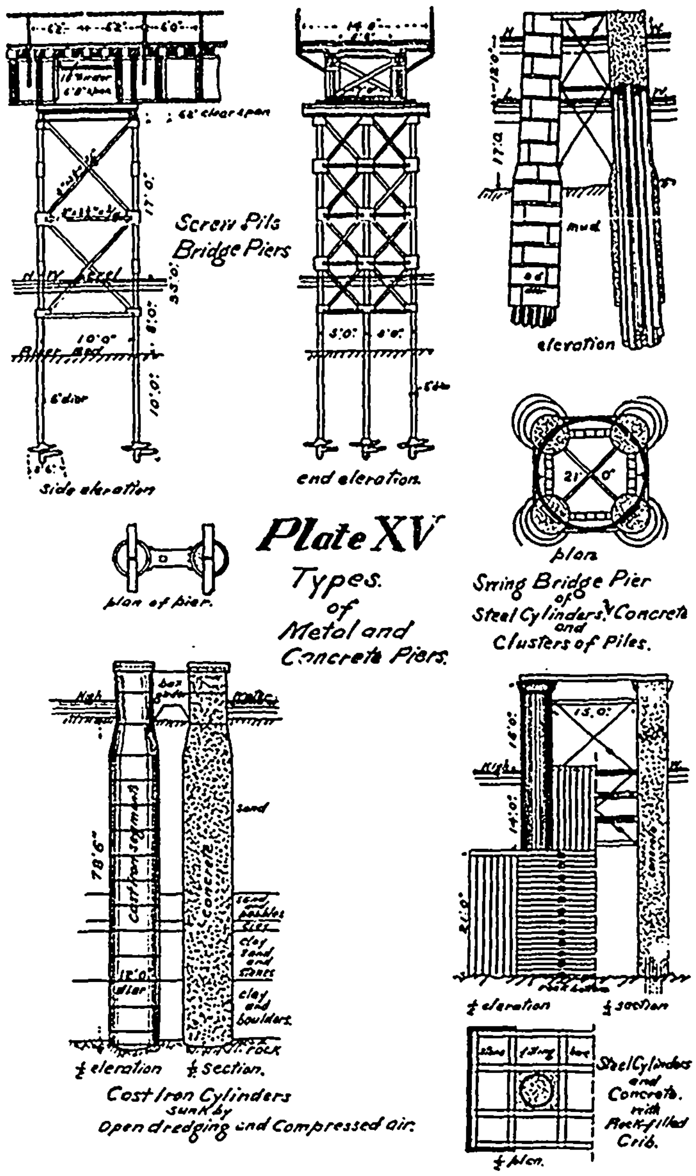
or otherwise brought to a smooth surface, and so arranged as to bring the pedestal plates of the trusses exactly on the centre of especially large coping stones of dimensions given on the plans."



ARTICLE 24.—METAL OR METAL AND CONCRETE PIERS.

On Plate XV. are shown several applications of metal and concrete for bridge piers. The method by screw piles founded in mud is quite unique and has not been attempted in America for railway bridge piers, but the steel cylinders filled with concrete and founded either in mud on piles or anchored to the rock by iron dowels are more familiar. For light highway bridges this method is quite suitable, but it is probable that, except in the form of one large cylinder, as a cofferdam to a pneumatic caisson, both filled with concrete and sunk in waters not needing cutwaters, their use for railway bridge piers will be exceptional, as the more massive forms shown on Plate XIV. will be better able to withstand the vibrations of trains and impacts of ice, etc.

ARTICLE 25.—IRON VIADUCTS OR TRESTLES.

The features usually under the control of the railway engineer are the general lay-out, the design and construction of masonry, and the erection of iron work; the detail designing of the iron being essentially a branch of bridge-work.

(*a*) *General lay-out.*—This has resolved itself in America to be, in general, a system of braced independent towers and suspended spans (see Fig. 54); the towers are usually about 30 feet spans, with posts vertical in side elevation; and, in end elevation, the girders are spaced 8 to 10 feet centres, and the posts battered at 2 to 3 inches per foot, depending on the allowance for wind, the aim being to avoid tension in the windward pedestals at the most unfavorable instant. The suspended spans are usually also plate girders of 30 feet to 60 feet span, depending on the height, the greatest economy being claimed when the cost of girders and longitudinal bracing is equal to the cost of towers and pedestal masonry. The usual design is with diagonal rods acting in tension and the girders resting on top of the posts, with slotted holes for expansion, but some late designs are for rigid, riveted bracing and posts extending to the tops of the girders, which are riveted to the webs of the posts, temperature changes being taken up in expansion pockets every 100 to 200 feet. This system is theoretically more rigid, but costs more and demands a perfect system of pedestals, any settlement being dangerous to a proper distribution of stress.

In estimating the weight of iron for approximate work, the following rule may be useful:

The weight of metal in the towers and bracings, in pounds, is equal to about 8½ times the longitudinal section area in square feet of the ravine below the line of girders and between the faces of abutments; this is based on a 100-ton consolidation engine and a high viaduct, say 100 feet, this will be changed to say 9½ times for a viaduct 50 feet high, and 10½ for a viaduct 35 feet high with the same weight of engine. The weight of girders, in pounds, may be estimated at $(9l+100)$ pounds per foot run of a span, where l = length of span. The price of iron varies considerably, with cost of erecting falsework, if any, and cost of erection and freight in general, but is about four cents per pound, in place, as a minimum. The floors of viaducts usually consist of say 8-inch by 10-inch oak ties about 12 feet long on their edge, boxed one-inch over the girders, and fastened to them by hooked bolts which pass through the guard rails and hook under the upper girder flanges; the spacing should be not more than six inches clear, and guard rails either double or with an inner guard rail of ordinary flanged rail. Some recent designs, however, call for solid floors of steel troughs filled with ballast and with ordinary track ties, which, certainly, would lessen vibration and increase safety in case of slight derailments.

(*b*) *Pedestal Masonry.*—The greatest care must be exercised in laying out and building the abutments and pedestals, as any error in position or appreciable one in height is very serious, because the iron work, being manufactured at a distance contemporaneously with the masonry, is shipped to the spot partially assembled, and cannot be afterwards altered except by a slight shimming up of pedestals built too low. The shoes of the columns are always bolted down to the copings, and in high structures these bolts should be built into the pedestals 5 or 6 feet, by passing through the stones as they are laid in place (see Fig. 54), the bolt holes are afterwards filled tight with sulphur, lead, or neat cement grout, while if the structure is not very high or subject to heavy winds, the anchor bolts are only sunk into the coping stones, dovetailed by wedges and cemented as before. Pedestal masonry is sometimes built of well burnt brick covered by a stone coping, and the use of monolithic concrete is especially adapted to this class of work, as it permits of the anchor bolts being buried in the concrete to any depth during construction. In any case the best class of work must be done, as the strains and thrusts acting are of higher intensity than in ordinary masonry, and the pedestal is not only under considerable vibration for so small a